EPSC Abstracts
Vol. 8, EPSC2013-555, 2013
European Planetary Science Congress 2013

In situ sounding of the shallow subsurface with a Radar to understand the nature of the landing site

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Abstract

The WISDOM (Water Ice Subsurface Deposit Observation on Mars) GPR has been designed to be accommodated on a rover and to investigate in-situ the Martian near subsurface down to a depth of a few meters with a vertical resolution of a few centimeters. We will present results obtained with a prototype of the instrument in both artificial and natural environments that illustrate the instrument performance in terms of vertical resolution and ability to perform 3D mapping of the sub-surface. We will show how the data collected provide insights into the origin and nature of the site.

1. Introduction

While the low frequency orbital Radars MARSIS and SHARAD have provided global results at the planet scale with a few tenths of meters of vertical resolution, missions involving a rover with a an onboard GPR offer the opportunity for a local and much more detailed characterization of the subsurface.

The WISDOM (Water Ice Subsurface Deposit Observation on Mars) GPR has been designed and selected for the ExoMars rover mission. Its scope is to investigate the Martian near subsurface down to a depth of a few meters (commensurate with the capacity of the mission's drill) with a vertical resolution of a few centimeters.

2. The instrument

The WISDOM GPR has been designed to investigate and characterize the nature of the subsurface remotely [1], providing high-resolution (several cm-scale) data on subsurface stratigraphy, structure, and the magnitude and scale of spatial heterogeneity.

To reach such a high spatial resolution, a broad frequency bandwidth is needed and this made the design of the radar's electronic unit and the antennas system [2] challenging. Despite the constraints of the space mission, decision was made to have an antenna system that allows to study depolarization effects [3].

Given the relatively high frequencies WISDOM is operating at, calibration on known targets (spheres or smooth plate) can easily be done in an anechoic chamber to get a reference signal. WISDOM will thus provide calibrated data and the amplitude of the received echoes will be used to retrieve the geoelectrical properties of the units detected in the subsurface.

A prototype representative of the instrument flight model is being used for tests in a variety of environments.

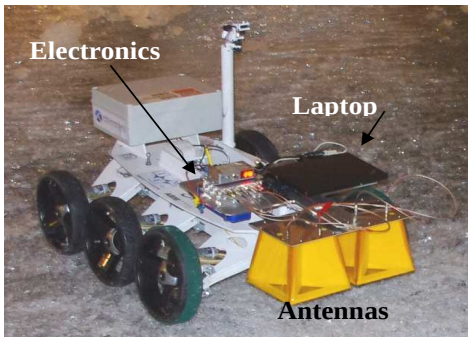

Figure 1: WISDOM accommodated on the MAGMA rover of the Polish Mars Society during the Dachstein Mars simulation organized by the Austrian Space Forum(April-May 2012, Austria).

3. Some results

WISDOM is operating at relatively high frequencies (approximately 100 times higher than the one used by the SHARAD radar), which is limiting the penetration into the subsurface. Nevertheless, measurements performed with WISDOM in natural environments have shown penetration down to 3

meters in pyroclatic deposits and in excess of 20 m in very favourable environments such as ice and snow.

The vertical resolution achieved is as expected a few centimeters depending on the actual subsurface properties.

When the soundings were performed according a rover path that covers the area of interest, it was possible to eventually reconstruct a 3D subsurface structure. During the recent field test in Dachstein, the PanCam team tracked the rover location, precise location of the radar was provided for each sounding and a 3D reconstruction of the subsurface structures was performed.

The polarimetric measurements proved to be useful to retrieve information on the shape and orientation of reflectors as well as to provide an indication of the location of off track reflectors.

4. Summary and Conclusions

A prototype of a radar to perform polarimetric high resolution soundings of the shallow subsurface of Mars has been developed for the ExoMars mission.

The fields tests performed so far have shown results in good agreement with the expected performance of the instrument.

WISDOM can easily be accommodated on any rover to be sent on Mars or on any other terrestrial body. WISDOM is versatile enough that it can adapt to slightly different situations: the distance of the antennas above the surface can be changed; the frequency band width can be slightly shifted toward lower frequencies to get deeper penetration provided that the volume allocated for the antenna is slightly increased

Acknowledgements

WISDOM development and this research are funded by the French space agency CNES and by the German space agency DLR. The authors wish to thank the Polish Mars Society for the use of their MAGMA Rover and the PanCam team who provided the 3D location of the Rover.

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